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The Other-Race Effect and its Influences on the Development of Emotion Processing

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THE OTHER-RACE EFFECT AND ITS INFLUENCES ON THE DEVELOPMENT OF EMOTION PROCESSING

A Thesis Presented

by

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ABSTRACT

THE DEVELOPMENT OF THE OTHER RACE EFFECT

AND ITS INFLUENCES ON EMOTION PROCESSING

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The theory of perceptual narrowing posits that the ability to make perceptual discriminations is very broad early in development and subsequently becomes more specific with perceptual experience (Scott, Pascalis, & Nelson, 2007). This leads to the formation of biases (Pascalis et al., 2002; 2005; Kelly et al., 2007), including the other-race effect (ORE). Behavioral and electrophysiological measures are used to show that by 9-months-of-age, infants exhibit a decline in ability to distinguish between two faces from another race compared to two faces from within their own race. Significant differences in the P400 component revealed a dampening of response to other-race compared to same-race faces for 9-month-olds only. More negative N290 amplitudes in response to happy compared to sad faces were found for 5-month-olds only. Nine-month-olds did not show different responses based on emotion, indicating that race was interfering with the processing of emotion.

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CHAPTER I

OBJECTIVES AND BACKGROUND

Introduction to Perceptual Narrowing

The theory of perceptual narrowing posits that the ability to make perceptual discriminations is broad early in development and subsequently becomes more specific with perceptual experience (Scott, Pascalis, & Nelson, 2007). This effect has been seen in both visual and auditory development. It has been shown that infants as young as 6-months can discriminate among phonemes from non-native languages. However, by 9 to 12 months of age this ability declines, and discrimination is found only for phonemes in one's native language (e.g., Werker & Tees, 1984). This same type of narrowing has also been shown in the development of visual processing, leading to the formation of biases (Pascalis et al., 2002; 2005; Kelly et al., 2007). Two such biases include: (1) the other-race effect (ORE) and (2) the other-species effect (OSE).

Studies of the ORE have shown that adults are much better at distinguishing between two faces within their own race compared to two faces of another race (e.g. MacLin & Malpass, 2003). Researchers have also used monkey faces to study visual perceptual narrowing in infants. The advantage of this is that they are similar to human faces in structure and layout, and infants typically do not have previous experience with them. Studies have found that between 6- and 9-months-of-age, the ability to make distinctions among monkey faces declines (Pascalis et al., 2002; 2005; Scott & Monesson, 2009). A similar decline is found between 6- and 9-months-of-age when infants are given the task of distinguishing among other-race faces (Kelly et al., 2007). These results suggest that biases within the face processing system (e.g., the ORE or OSE) originate in infancy and

are a product of perceptual narrowing. However, the mechanisms mediating perceptual narrowing are not currently well understood. The present investigation aimed to further elucidate the behavioral and neural properties of perceptual narrowing and the development of the ORE during infancy.

Scott, Pascalis, and Nelson (2007) posit that perceptual narrowing may be dependent on the level of categorization at which visual perceptual stimuli are learned. Adult (Tanaka & Pierce, 2009) and infant research (Scott & Monesson, 2009) suggests that labeling faces at the individual level, rather than the categorical level, is particularly important for learning to distinguish among faces. In addition, adult research on the acquisition of perceptual expertise suggests that adults recognize faces and objects of expertise at a more specific level (i.e., subordinate or individual level) than they do other categories of objects (Scott et al., 2006; 2008). Recent results suggest that this may also be mediating perceptual narrowing during development (Pascalis et al., 2005; Scott & Monesson, 2009). More specifically, a longitudinal study using measures of looking time before and after training showed that when infants were given experience with six, individually labeled, monkey faces (i.e., each of the faces was paired with its own name) over a three-month training period, they maintained the ability to discriminate these faces after training. This training generalized to new exemplars within the same species (Scott & Monesson, 2009). However, learning to categorize six monkey faces (i.e. each face was labeled “monkey”) or just being exposed to six monkey faces (no label) led to the typically observed decline (Scott & Monesson, 2009). These findings highlight the importance of early experience, particularly individuating experience, in the development of face processing. Significant discrepancies are found in the frequency of interaction that

infants have with same- versus other-race faces, with more than 90% of experience being with same- relative to other-race faces (Rennels & Davis, 2008). Combined, this research indicates that this difference in experience could influence the way in which faces are categorized, thus mediating the effects of perceptual narrowing.

Researchers have used behavioral techniques to try to determine the nature of the development of the other-race effect during the first year of life (Sangrigoli & de Schonen, 2004; Hayden et al., 2007; Kelly et al., 2005; Kelly et al., 2007; Scott & Monesson, 2009). Three-month old infants, but not newborns, prefer to look at faces of their own race over faces from another racial group (Kelly et al., 2005). This looking preference is suggested to be the result of predominant exposure to faces of one's own race, and that experience tunes the face processing system to own-race faces, resulting in impairments recognizing other-race faces in adulthood (Kelly et al., 2005). In a follow-up investigation, Kelly and colleagues (2007) found that the ability to discriminate own- and other-race faces declines from 6- to 9- months of age. These results suggest that perceptual experience leads to a superiority effect, whereby an early preference for own-race faces leads to more experience with own- compared to other-race faces. This results in an increase in the ability to accurately distinguish own- relative to other-race faces, or, perceptual narrowing.

The effects that this narrowing has on other areas of perceptual processing were previously unknown. However, several theories have been posited to explain the other-race effect. One such theory, the "race as a feature hypothesis" (Levin, 1996), suggests that race is treated as a feature in visual processing and that further visual processing is not undertaken once the brain has detected that the face is of an unfamiliar race. Another

theory suggests that the other-race effect is the result of an inability to process other-race faces holistically (Tanaka et al., 2004). Typically, faces are processed holistically rather than featurally, as objects are (Tanaka et al., 1998). Evidence for this comes from studies finding disruption of face, but not object, recognition when inverted (Yin, 1969; Freire, Lee, & Symons, 2000; see also Scott, Tanaka, & Curran, in press for review).

From this line of research, it follows that certain perceptual characteristics (e.g., race) may subsequently disrupt holistic processing (O'Toole et al., 1996). O'Toole and colleagues found that the ORE disrupts the efficiency of perceptual processes other than just recognition abilities, such as sex discrimination. Adult participants were shown a same- or other-race male or female face for 75ms, followed by a 250ms mask, and then asked to indicate, via button press, whether the face had been male or female. Participants' responses were more accurate in reference to same- compared to other-race faces (O'Toole et al., 1996). This finding suggests that race may be being processed separately from, and superordinately to, sex information.

A more recent study attempted to replicate this finding with infants (Quinn et al., 2008). A consistent finding in developmental face literature, is an infant preference for female relative to male faces (Leinbach & Fagot, 1993; Quinn et al., 2002; Quinn & Slater, 2003). Infants as young as 3-months exhibit a spontaneous visual preference for female faces when paired with male faces; when the primary caregiver is male, infants prefer male faces (Quinn & Slater, 2003). However, infants raised by their mothers only exhibited a preference for female faces when the two faces were of their own race; no preference was found for male or female other-race faces (Quinn et al., 2008). This finding suggests that biases resulting from perceptual narrowing (i.e., the ORE),

influence the ability to extract other important perceptual features of the face, including sex. The current research will extend this finding to examine the development of the other race effect in infancy and how it influences the development of emotion processing. Based on previous findings (O'Toole et al., 1996; Quinn et al., 2008), it is logical to suggest that perceptual narrowing may not just influence other perceptual aspects of face processing, but perhaps other cognitive and social/emotional face processes.

ERPs and Face Perception

The current study uses both behavioral and electrophysiological measures (event-related potentials, or ERPs). The infant literature is best understood within the context of adult research, as much of infant ERP research is based on phenomena observed in adults. Those ERP components relevant to face processing research are reviewed.

One adult ERP component, the N170, is a negative deflection that occurs around 170 milliseconds after the presentation of a face or object. The N170 has been called a "face detector", because it has a much larger amplitude response and, often, shorter latencies to human faces than other objects (Bentin et al., 1996; Carmel & Bentin, 2002; Rossion et. al., 2000; Taylor et al., 1999), especially over the right hemisphere (Itier & Taylor, 2002; Carmel & Bentin, 2002). Larger amplitudes and, sometimes, longer latencies are observed in response to inverted compared to upright faces, which is suggested to be a result of a disruption of configural processing (Bentin et al., 1996; de Haan, Pascalis, & Johnson, 2002; Eimer, 2000; Itier & Taylor, 2002; Rossion et al., 2000). This increase is found only in response to inverted *human* faces (de Haan, Pascalis, & Johnson, 2002). Because this response is species-specific in adults but not in infants (reviewed below), it supports the theory of perceptual narrowing.

While it has been shown that the N170 is sensitive to global properties of faces, it does not seem to respond differentially to familiarity (Caharel et al., 2009) or race (Caldara et al., 2003; Caldara et al., 2004; James et al., 2001). It seems as though a slightly later component known as the N250 is indexing such individuating and specific face information (Tanaka & Pierce, 2009). The N250 is not a general index of face processing, but one that seems to depend upon the specificity of categorization (Scott et al., 2006; 2008). Faces or objects that are learned individually evoke stronger N250 responses than those learned categorically or through simple exposure (Scott et al., 2006; 2008; Tanaka et al., 2006; Tanaka & Pierce, 2009).

While there is no identical "infant N170," a negative deflection differentiating human and non-human primate faces was detected at a slightly longer latency than the adult N170 (the N290) (e.g., Bentin et al., 1996). Unlike the adult N170, the infant N290 shows larger amplitudes in response to human compared to monkey faces (de Haan, Pascalis, & Johnson, 2002; Halit et al., 2003). There was also no difference in response to upright versus inverted faces; however, the later P400 component was larger for upright than inverted monkey *and* human faces (de Haan & Nelson, 1999; Scott & Nelson, 2006; Scott, Shannon, & Nelson, 2006). Further evidence that the P400 is a precursor to the adult N170 comes from findings showing that it also is more prominent at right lateral electrodes than medial electrodes (de Haan & Nelson, 1999; Scott & Nelson, 2006; Scott, Shannon, & Nelson, 2006). These results suggest that the development of the electrophysiological indices of face processing is, at first, distributed across two components and then with development becomes more specialized, leading to the adult-like N170 response (de Haan, Pascalis & Johnson, 2002).

While the research relating the infant N290 and P400 to the adult N250 is not as established or extensive as for the N170, it is reasonable to suggest that the N290 and P400 are precursors to both adult components. Previous research has shown that, like the N250, these components respond differentially to familiar compared to unfamiliar stimuli as well as stimuli learned at more subordinate levels (Scott, Shannon, & Nelson, 2006).

Another ERP component that has been investigated in developmental populations is the Nc or the negative central component. The Nc is typically elicited around 400-600 milliseconds after stimulus onset and is related to attentional processes (e.g., de Haan & Nelson, 1999; Ackles & Cook, 2007). In studies of face processing, the Nc has been found to be larger in response to unfamiliar compared to familiar faces (de Haan et al., 2004), negative compared to positive emotions (Grossman et al., 2006; Leppanen et al., 2007), and incongruent compared to congruent visual and auditory emotional cues (Grossman et al., 2006).

Emotion Processing

Infants and adults use information about affect and emotion to make distinctions among faces and decide what responses are appropriate in a given situation (Batty & Taylor, 2006). By about 3.5-months-of-age, infants are able to successfully match emotion sounds (happy/sad) with appropriate static face images; however, this ability is limited to familiar faces and sounds (e.g., the father) and does not generalize to strangers (Montague & Walker-Andrews, 2001). By 5-months-of-age, infants are able to correctly categorize emotions of static images, as well as recognize an individual across various levels of expression of a single emotion (Bornstein & Arterberry, 2003). Research using ERPs has shown that by seven-months-of-age, infants are able to make distinctions

among different facial expressions (Leppanen et al., 2007). In this study, both adults (N170) and infants (P400) showed larger amplitude responses for fearful faces than either happy or neutral expressions (Leppanen et al., 2007).

Additional evidence of infants' ability to differentially process emotions comes from an investigation showing that infants whose mothers showed greater positive affect when interacting with them exhibited a larger amplitude in the Nc component to fearful than happy faces (de Haan et al., 2004). These authors suggested that the larger amplitude Nc is due to the relative lack of experience infants have with fearful expressions. This unfamiliarity response might also be present in response to other-race faces, because infants also have a lack of individuating experience with these types of faces. These results suggest that infants are able to identify emotions in familiar types of faces, but it is unknown whether this ability will be diminished when viewing emotion expressions in other-race faces. If the effects of perceptual narrowing encompass cognitive areas outside of face processing, then it is expected that the ability to distinguish among emotions will be negatively affected when the stimuli are of other-race faces.

If young infants can recognize and distinguish among faces, and they are able to make distinctions among emotional sounds, the next question is whether or not infants are able to successfully integrate this information. Grossman and colleagues (2006) found that in 7-month-olds, the Nc was larger in response to incongruent compared to congruent face/voice emotion pairs. These results suggest that infants can successfully integrate multimodal information and use this information to recognize a congruent face/voice affect match (Grossman et al., 2006). The current investigation seeks to discover if this ability extends to a younger age group (i.e., 5-month-olds), and whether it is negatively

affected by perceptual narrowing. If race is processed superordinately to other perceptual features of faces (Tanaka et al., 2004), then the presence of the ORE by 9-months-of-age will decrease infants' ability to correctly match face/voice emotion pairs. It is important to determine how extensive the effects of visual perceptual narrowing on other cognitive processes are.

CHAPTER II

THE CURRENT STUDY

Hypotheses

The goal of the current research is to examine the development of the other-race effect with respect to perceptual narrowing across the first year of life, in order to study its neural correlates and the impact that it has on other areas of cognitive development. Both behavioral and electrophysiological measures are used to answer the following questions: (1) Do infants display behavior typical of the other-race effect, as measured by VPC? (2) Does behavioral evidence of the other-race effect translate into differential neural processing of same- and other-race faces? (3) Is the development of emotion processing influenced by visual perceptual narrowing during the first year of life?

It is expected that results of the VPC will replicate previous findings (Kelly et al., 2007). Five-month-old infants will display novelty preferences for same- and other-race faces, whereas 9-month-olds will only show novelty preferences for same-race faces. Additionally, pair-wise comparisons will show that 9-month-old infants are exhibiting different looking behavior for same- compared to other-race faces, but 5-month-olds will not exhibit this difference.

It is expected that analyses of ERP data will show a dampening of the response to other-race compared to same-race faces in 9-month-olds. This will be evidenced by a larger amplitude at the P400 in response to same- compared to other-race faces, based on research indicating larger amplitude P400 responses to familiar compared to unfamiliar stimuli (e.g., Scott & Nelson, 2006; Scott, Shannon, & Nelson, 2006). Adult research has also shown increased negativity and delayed responses for the N170 in response to other-

compared to same-race faces (Stahl, Wiese, Schweinberger, 2008), providing further support for this hypothesis. However, 5-month-old infants will show no race-dependent effects, as they are not yet showing the behavioral effects consistent with perceptual narrowing, as based on previous behavioral research (Kelly et al., 2007).

It is also expected that 5-month-old and 9-month-old infants will be able to distinguish between Happy and Sad images (de Haan et al., 2004; Grossman et al., 2006; Leppanen et al., 2007). These differences should be present in both the perceptual components (N290 & P400) and the attentional component (Nc), though previous studies have focused primarily on the Nc in studies of emotion discrimination. As such, it is hypothesized that at the Nc, Sad faces will elicit larger amplitude responses at 5-months than will Happy faces. However, based on familiarity literature (Scott, Shannon & Nelson, 2006), the direction of the effect is expected to be the opposite at the perceptual components; larger amplitudes will be elicited by Happy images compared to Sad images. If the visual bias resulting from perceptual narrowing (i.e., the ORE) interferes with the processing of other perceptual characteristics, then these emotion-dependent differences will not be seen for 9-month-old infants.

Finally, the current investigation is concerned with the multi-modal processing of emotion information. It is expected that 5-month-old infants will exhibit behavior consistent with what was reported by Grossman and colleagues (2006), showing increased Nc responses to incongruent compared to congruent face/voice pairs. However, because of the effects of perceptual narrowing, it is predicted that 9-month-old infants will only show this congruency-dependent effect for same-race face/voice pairs, and the effect will be diminished or not present for other-race face/voice pairs.

Experimental Procedures

The following study used electrophysiological and behavioral techniques to examine whether infants' ability to correctly pair emotional expressions with sound is impaired when the faces are of a race other than one's own. Participants included infants from two different age groups: 5- and 9-months-of-age. These ages were chosen based on previous research examining the development and effects of perceptual narrowing (Kelly et al., 2005; 2007; Pascalis et al., 2002; Scott & Monesson, 2009). Infants completed a behavioral (VPC) task and passively viewed pairs of congruent and incongruent face/voice pairs while ERPs were recorded.

Participants

All infants were from the western Massachusetts area. The Massachusetts Office of Vital Statistics provided birth record information, and infants were recruited via mailings and phone calls. Each infant came to the lab for a single one-hour session, during which time s/he completed both a behavioral VPC and an electrophysiological task. Each parent was given $10 for participation, and the infant received a small toy.

Participants for the behavioral portion of the study included 17 5-month-old (mean age=155 days, SD=7.12 days) Caucasian infants (10 male, seven female) and 21 9-month-olds (mean age=274 days, SD=9.78 days) Caucasian infants (14 male, seven female). An additional 33 were excluded due to not completing the test (n=1), experimenter or technical error (n=5), because they became fussy during testing (n=1), exhibited a side bias (n=15), because they failed to fixate both images during test trials (n=7), or because the faces used as stimuli were neither same- nor other-race images

(n=2) or were both same- and other-race images (n=2) due to the infants' racial background.

Participants for the electrophysiological portion of the study included 14 5-month-old (mean age=156 days, SD=6.45 days) Caucasian infants (eight males, six females) and 14 9-month-old (mean age=273 days, SD=8.52 days) Caucasian infants (nine males, five females). An additional 22 participants were excluded because they became fussy during testing (n=15) or they did not have enough trials per condition (n=7). All infants were born full term and had no visual or neurological abnormalities.

Stimuli

Ten different 800 ms clips of a female voice laughing or crying were used for the auditory stimuli in this experiment. The images were of eight different African American (4 happy, 4 sad) and eight different Caucasian (4 happy, 4 sad) female faces, obtained via the MacArthur NimStim face set (Tottenham et al., in press). Low-level perceptual differences (e.g., luminance) across stimuli were reduced using a program in MatLab called "Shine", and all images were generated in black and white. When displayed on the screen, each image was approximately 15.5 cm high and 12.5 cm wide, presented at a visual angle of approximately 13.6 degrees. During testing, the faces and sounds appeared on a grey and white, patterned background.

Behavioral Procedures

To measure visual discrimination, researchers (e.g., Pascalis et al., 2002; Kelly et al., 2005; 2007; Scott & Monesson, 2009) use preferential looking paradigms and measure infants' looking duration and direction of fixation. One such paradigm is the visual-paired comparison (VPC) method (Fantz, 1963). This method capitalizes on infants'

preference for novelty after familiarization (for review see Snyder, 2007). If infants show a significant novelty preference, one can infer that infants discriminate the novel from the familiarized stimulus (Snyder, 2007). This procedure has been used extensively in developmental research to examine abilities such as phoneme discrimination (Werker & Tees, 1994) and face recognition (e.g., Morton & Johnson, 1991; see Johnson & de Haan, 2001 for review). These techniques have also been used in studies of both the other-species and other-race effects (e.g., Pascalis et al., 2005; Scott & Monesson, 2009).

Infants first completed a visual-paired comparison (VPC) task to determine whether or not they could distinguish among same- and other-race happy female faces. Infants were placed on their caretaker's lap in front of a 19-inch computer monitor. A digital camera recorded the infants as they completed this task. For familiarization, infants were shown two images of the same smiling female face side-by-side (either African American or Caucasian, condition counter-balanced for order of presentation across participants; two stimuli sets were also counterbalanced across participants to account for possible stimulus effects) on a gray and white patterned background for an accumulated looking time of 30 seconds. An experimenter viewed a live video feed of the infant during this task and indicated when the infant was looking via button press, allowing time to be kept. Next, infants viewed the familiarized face paired with a new face of the same race, for an accumulated looking time of five seconds; these faces then switched sides for another five seconds to account for any possible side looking biases. After this, infants completed a second VPC task, as described above, using the faces from whichever race was not presented first (See Figure 1). To calculate duration of fixation, the video was slowed to about 20% of the normal speed, and eye fixations to each stimulus were coded using The

Observer XT 7.0. Percent time looking toward the novel stimulus was compared for same- and other-race faces.

Two separate observers (inter-observer agreement ~85%), blind to the conditions, coded proportion looking to the familiar and novel images. Measures of looking time were averaged across the two five-second test trials and then converted into percent fixation for the novel stimuli. The average amount of time spent looking at the novel and familiar images was calculated across participants. One-sample t-tests compared the percentage of time spent looking at the novel image to what would be expected at chance (50%); this was done for both same-race and other-race trials. Pair-wise comparisons determined whether looking behavior toward the same-race novel stimuli differed from looking behavior toward the other-race novel stimuli. Because these t-tests are based on a priori hypotheses, p-values are not corrected for multiple t-tests.

Electrophysiological Procedures

After infants completed the VPC task, a 128-channel Geodesic Sensor Net (Electrical Geodesics, Inc., Eugene, Oregon) connected to a DC-coupled 128-channel, high input impedance amplifier (Net Amps 300, Electrical Geodesics) was fitted to each infant while they sat on their caregiver's lap. After net placement, infants passively viewed approximately randomized trials (160 possible), including incongruent (e.g., Happy Sound, Sad Face or Sad Sound, Happy Face) and congruent (e.g., Happy Sound, Happy Face or Sad Sound Sad Face) African American and Caucasian face/voice pairs. Each trial began with a black fixation cross-presented on a grey and white patterned background to direct attention to the screen. This fixation cross was followed by an 800 ms sound clip of a female voice expressing either a happy (laughing) or sad (crying)

emotion, followed by another fixation cross (500 ms) and finally a happy or sad female face (either African American or Caucasian) for 500ms. A minimum of 900ms separated the presentation of each trial (See Figure 2). Trials were only presented when participants were fixating the computer screen.

Amplified analog voltages (0.1-100 Hz bandpass) were digitized at 500 Hz. Impedances were accepted if they were less than 50 kΩ. Post-recording segmentation and averaging was completed using Netstation 4.3 (Electrical Geodesics, Inc., Eugene, OR). Trials were discarded from analyses if there were more than 12 bad channels (changing more than 300 microvolts in and individual segment, or if it was marked bad in more than 30% of the trials). Individual channels that were consistently bad (off-scale on more than 70% of the trials) were replaced using a spherical interpolation algorithm (Srinivasan et al., 1996). Participants' ERPs were segmented and averaged to the different conditions for each group. Participants with fewer than 10 artifact free trials per condition were excluded from analyses. For 5-month-olds, an average of 89 trials (SD=18.54) were completed in all. An average of 44 trials (SD=9.27) were completed in each of the inclusive conditions (i.e., Black/White or Happy/Sad or Congruent/Incongruent) and 22 trials (SD=4.63) in each of the exclusive conditions (e.g., Happy Black, Happy Congruent). For 9-month-olds, an average of 83 trials (SD=22.50) were completed in all. An average of 42 trials (SD=11.19) were completed in each of the inclusive conditions and 21 (SD=5.60) in each of the exclusive conditions.

ERPs were baseline corrected with respect to the 100-ms pre-stimulus recording interval and digitally low pass filtered at 40 Hz. An average reference was used to

minimize the effects of reference site activity and accurately estimate the scalp topography of ERPs recorded from a high-density electrode montage (Dien, 1998).

Groups of electrodes were chosen over occipto-temporal regions for the N290 and P400, based on previous research (de Haan & Nelson, 1999; Scott & Nelson, 2006; Scott, Shannon, & Nelson, 2006) and visual inspection of the data. However, the electrode groupings used were slightly larger than conventionally analyzed, because observed differences in the distribution of visual evoked potentials in the current and previous studies suggested a more exploratory analysis including all posterior electrodes (Figure 3). Thus, all electrodes showing a P400 were included in analyses: Left (L): 57, 58, 63, 64, 65, 68, 69, 70, 73, 74; Right (R): 82, 83, 88, 89, 90 94, 95, 96, 99, 100 (See Figure 4). Mean amplitude and latency were measured for the N290 within the window of 172-342ma for 5-month-olds and 214-358ms for 9-month-olds. The window for the P400 was within 308-470ms for 5-month-olds and 320-500ms for 9-month-olds.

A similar selection process was used to determine selection of electrodes for Nc component analysis (Balas & Nelson, 2009; Rigato, Farroni, & Johnson, 2009). Electrodes were chosen from a frontal location (4, 5, 10, 11, 12, 16, 18, 19) and a central location (REF, 7, 31, 54, 55, 79, 80, 106) (See Figure 5). Mean amplitude and latency of the Nc component were measured within the window of 298-750ms after visual stimulus onset for both age groups.

There were too few trials to analyze the data as a 2 (Race: Black, White) x 2 (Emotion: Happy, Sad) x 2 (Congruency: Congruent, Incongruent) x 2 (Hemisphere) repeated measures ANOVA. Thus, original broad analyses are done using a 2 x 2 x 2 multivariate analysis of variance (MANOVA) with two levels of Race (Black, White), 2

levels of either Emotion (Happy, Sad) or Congruency (Congruent, Incongruent) and two levels of Hemisphere (L,R). All MANOVA main effects and interaction effects are corrected using Bonferroni. Follow-up tests are in the form of paired t-tests, and those not based on a priori hypotheses (this excludes t-tests for the behavioral comparisons) are also Bonferroni corrected. Only significant and marginally significant results are reported.

While latency and amplitude differences are reported and discussed, it is important to remember that the inferences that can be made with respect to each variable are different. Often, latency differences in early perceptual components point to differences in the speed of neural processing, whereas amplitude differences indicate discrepancies in the load of processing (Luck, 2005).

Results

Behavioral Results

A t-test comparing novelty preferences to 50% revealed that, as expected, 5-month old infants exhibited significant novelty preferences for both the same- (M=61.58, SE=3.05) and other- (M=59.57, SE=4.06); race female faces (t(16)=3.80, p=.002 and t(16)=2.36, p=.032), respectively). By 9-months-of-age, infants exhibited novelty preferences for same-race female faces (M=56.92; SE=2.95) but not for other-race female faces (M=53.20, SE=3.35), (t(20)=2.35, p=.029) and t(20)=0.955, p=.351), respectively). However, a pair-wise comparison between same- and other-race novelty preferences was

not significant (t(20)=1.02, p=.322)[1]; the same analysis was not significant for 5-month-old infants (t(15)=0.35, p=.732) (See Figure 6).

Electrophysiological Results

5-Month-Olds

N290

Mean Amplitude. A 2 x 2 x 2 Race X Congruency X Hemisphere MANOVA revealed no significant results.

A 2 x 2 x 2 Race X Emotion X Hemisphere MANOVA revealed a main effect of emotion (F(1,13)=5.40, p=.037, h_p^2=0.29, observed power=0.58). Mean amplitude of the N290 was significantly more negative in response to Happy (M=4.97, SE=1.36) as compared to Sad (M=7.63, SE=1.15) faces (See Figure 7).

Latency. A 2 x 2 x 2 Race X Congruency X Hemisphere MANOVA revealed no significant effects.

A 2 x 2 x 2 Race X Emotion X Hemisphere MANVOA revealed a three-way interaction (F(1,13)=5.22, p=.040, h_p^2=0.29, observed power=0.56). This interaction was being driven by shorter latency responses for White Happy faces in the Right Hemisphere (M=273.16, SE=6.27) compared to longer latencies for White Sad faces in the Right Hemisphere (M=286.64, SE=6.89) (See Figure 8). However, corrected follow-up t-tests revealed that this difference was not significant, (t(13)=-2.20, p=.56)

P400

Mean Amplitude. No significant effects were found.

[1] An ANOVA was also done to see if novelty preference differed based on the race of the face. It was not significant for 5-month-olds (F(1,32)=0.16, p=.70) or 9-month-olds (F(1,40)=0.70, p=.41).

Latency. A 2 x 2 x 2 Race X Congruency X Hemisphere MANOVA revealed a Congruency X Hemisphere interaction ($F(1,13)=7.22$, $p=.019$, $h_p^2=0.36$, observed power=0.70). Follow-up t-tests revealed this was due to a difference in amplitude between congruent trials in the Right (M=415.79, SE=8.42) compared to the Left (M=435.24, SE=7.32) hemisphere. However, corrected t-tests were not significant ($t(13)=2.06$, $p=.24$) (See Figure 9).

A 2 x 2 x 2 Race X Emotion X Hemisphere MANOVA revealed no significant effects.

Nc

Mean Amplitude. No significant effects were found.

Latency A 2 x 2 x 2 Race X Emotion X Region MANOVA revealed a significant 2-way interaction (Emotion X Region) ($F(1,13)=5.67$, $p=.033$, $h_p^2=0.30$, power=0.60). Follow up t-tests revealed that this effect was being driven by shorter latencies to Happy trials at the central location (M=470.77, SE=19.57) compared to the frontal location (M=498.63, SE=20.80) and compared to Sad trials at the central location (M=495.54, SE=18.94). However, neither of these comparisons was significant after corrections ($t(13)=1.52$, $p=.60$, and $t(13)=1.71$, $p=.44$, respectively) (See Figure 10).

Summary of Results, 5-Month-Olds

Behavioral results replicate the finding (Kelly et al., 2007) that infants are able to distinguish between two images of their own race, as well as two images of another race. Analyses of the ERP results show that 5-month-old infants are making distinctions based on the emotion of the face, as evidenced by greater negativity at the N290 in response to Happy as compared to Sad faces, but, importantly, that this is independent of race.

Analyses of the Nc component suggest that infants are processing positive and negative emotions differently, but the lack of significant follow-up comparisons makes it difficult to ascribe meaning.

9-Month-Olds

N290

Mean Amplitude. A 2 x 2 x 2 Race X Congruency X Hemisphere MANOVA revealed a significant main effect of Hemisphere ($F(1,13)=7.32$, $p=.018$, $h_p^2=0.36$, observed power=0.71), due to more negative amplitudes in the Left (M=3.00, SE=1.33) as compared to the Right (M=5.02, SE=1.11) hemisphere (See Figure 11).

A 2 x 2 x 2 Race X Emotion X Hemisphere MANOVA revealed a significant Main effect of Hemisphere ($F(1,13)=4.52$, $p=.053$, $h_p^2=0.26$, observed power=0.50), such that amplitudes were more negative in the Left (M=3.25, SE=1.35) as compared to the Right (M=4.96, SE=1.13) hemisphere (See Figure 12).

Latency. No significant effects were found.

P400

Mean Amplitude. A 2 x 2 x 2 Race X Congruency X Hemisphere MANOVA revealed no significant effects.

A 2 x 2 x 2 Race X Emotion X Hemisphere MANOVA revealed a significant main effect of Race ($F(1,13)=4.53$, $p=.053$, $h_p^2=0.29$, observed power=0.50). The effect was due to White (M=16.72, SE=2.78) faces eliciting larger P400 amplitudes as compared to Black faces (M=12.90, SE=2.24) (See Figure 13).

Latency. A 2 x 2 x 2 Race X Congruency X Hemisphere MANOVA revealed a significant main effect of hemisphere ($F(1,13)=12.22$, $p=.004$, $h_p^2=0.48$, observed

power=0.90), such that the P400 peaked later in the Left (M=397.94, SE=5.65) as compared to the Right (M=384.87, SE=5.31) hemisphere (See Figure 14).

A 2 x 2 x 2 Race X Emotion X Hemisphere MANOVA revealed a significant main effect of hemisphere (F(1,13)=11.86, p=.004, h_p^2=0.48, observed power=0.89). The P400 took longer to peak in the Left (M=399.07, SE=5.16) as compared to the Right (M=386.19, SE=5.24) hemisphere (See Figure 15). Additionally, a Race X Hemisphere interaction was revealed (F(1,13)=4.86, p=.046, h_p^2=0.27, observed power=0.53). Follow-up t-tests showed this to be due to a later P400 peak to Black faces in the Left hemisphere (M=399.80, SE=7.74) than in the Right hemisphere (M=388.20, SE=8.67); however, corrected follow-up t-tests revealed this to be not significant (t(13)=2.28, p=.16) (See Figure 16). A significant difference was found between responses to White faces in the Left hemisphere (M=398.63, SE=6.01) compared to the Right hemisphere (M=377.10, SE=5.09) (t(13)=4.67, p=.004) (See Figure 16).

Nc

Mean Amplitude. A 2 x 2 x 2 Race X Congruency X Region MANOVA revealed a significant 3-way interaction (F(1,13)=9.52, p=.009, h_p^2=0.42, observed power=0.81). Follow-up t-tests showed this interaction was due to greater amplitude responses to Black Congruent (frontal, M=-13.31, SE=2.77) compared to Black Incongruent (frontal, M=-8.10, SE=1.91) trials, (t(13)=-3.37, p=.02) (See Figure 17).

Latency. A 2 x 2 x 2 Race X Congruency X Region MANOVA revealed a significant 3-way interaction (F(1,13)=4.52, p=.053, h_p^2=0.26, observed power=0.50). Follow-up t-tests showed this to be the result of a later Nc to peak to Black Congruent trials in the frontal region (M=457.59, SE=27.29) compared to the central region (M=422.57,

SE=17.28) (See Figure 18) and to Black Congruent (frontal, M=457.59, SE=27.29) compared to White Congruent (frontal, M=403.50, SE=16.66) trials (See Figure 19). However, neither of these effects was significant once t-tests had been corrected (t(13)=2.31, p=.46 and t(13)=-2.12, p=.65, respectively).

Summary of Results, 9-Month-Olds

Behavioral results replicate the finding (Kelly et al., 2007) that by 9-months-of-age, infants are showing a decrease in ability to differentiate among faces of another race, compared to their ability to complete the same task with faces from their own race. Significant novelty preferences for own- but not other-race faces were found. However, the lack of a significant pair-wise comparison suggests that 9-month-old infants are not treating same- and other-race faces differently enough to be detected by statistical analyses. This will be further discussed below.

Electrophysiological results show that, at 9-months-of-age, infants are treating same- and other-race faces differently, as evidenced by the significant amplitude difference for the P400 in response to Black as compared to White faces. This difference is in the expected direction, such that mean P400 amplitudes are larger for White as compared to Black faces. Additionally, 9-month-olds are showing more hemispheric specialization, compared to the 5-month-olds, as evidenced by the latency differences between the Left and Right hemispheres. Importantly, these latency differences seem to suggest faster processing in the right hemisphere, which is consistent with previous work showing right lateralization of face processing (see de Haan, Johnson, & Halit, 2003 for review). These differences are also dependent on race, which further suggests that 9-month-olds are

showing a deficit in processing other-race faces. Finally, analyses of the Nc component reveal interaction effects between congruency and race.

Discussion

The current research used behavioral and electrophysiological techniques in order to determine the neural correlates of the other-race effect and the influences that this bias has on other areas of perceptual processing. While many of the expected findings were not revealed, we showed that 9-month-olds do in fact show differential neural responses to same- compared to other-race faces, as evidenced by the P400 component. Additionally, it is feasible to suggest that this bias is interfering with emotion processing in 9-month-old infants. A limitation of this study, as evidenced by effect sizes and power of analyses, was a small sample size and low trial counts.

Behavioral Portion

The results of the behavioral data lend support to the theory of perceptual narrowing. Five-month-old infants show significant novelty preferences for same- and other-race faces; 9-month-old infants only show a novelty preference for same-race faces. While the pair-wise comparison for the 9-month-olds was not significant as expected, the pattern of novelty preferences follows previously reported behavior (Kelly et al., 2007).

It is possible that the current research did not replicate previous findings because of differences in the paradigm. First, previous research used a habituation paradigm, whereas the current study used a VPC paradigm (Kelly, et al., 2007). Habituation paradigms individualize familiarization to each participant and VPC does not. Thus, it is possible that the pair-wise comparison is not significant, because infants were either not fully familiarized before the test phase, or they had disengaged attention due to the

familiarization lasting too long. More likely, however, is the difference in presentation of stimuli. The patterned background was used for the ERP task in order to keep infants focused on the screen between the presentation of the sound and the face; for consistency, the same background was used for the VPC task. However, the backgrounds are usually plain black in looking paradigms in order to limit distractions (Kelly et al., 2005; 2007; Scott & Monesson, 2009). It is possible that the presence of this patterned background disrupted looking behavior.

The decline seen in the current investigation and previous research using other-race faces (Kelly et al., 2007) follows the same pattern as research using other-species faces (Pascalis et al., 2005). A recent study has shown that individual (but not category or exposure) level training with other-species faces from 6- to 9-months can attenuate the decline in discrimination abilities generally seen during this time (Scott & Monesson, 2009). Future research should attempt to extend these training methods (Scott & Monesson, 2009) to other-race faces, as the current study suggests that the ways in which individual versus category level training influences perceptual abilities may be the same.

Electrophysiological Portion

Perceptual Components: N290 and P400

As expected, no significant race-dependent effects were found for the 5-month-olds. Previous behavioral results have shown that infants of this age are not yet exhibiting behavior typical of the ORE (Kelly et al., 2007), and thus are not showing neural patterns that would be expected as a result of the ORE. However, in support of our hypothesis, a significant main effect of Race for 9-month-olds was found for the P400 component. The presentation of an other-race face reduces P400 amplitude relative to same-race faces.

This is in line with adult research showing increased negativity and delayed responses for the N170 in response to other- compared to same-race faces (Stahl, Wiese, Schweinberger, 2008), as well as infant studies reporting larger amplitude P400 responses to familiar compared to unfamiliar stimuli (e.g., Scott & Nelson, 2006; Scott, Shannon, & Nelson, 2006). Additionally, expertise literature has shown that objects of expertise elicit greater N170 components than those with which the individual is not expert (Scott et al., 2006; 2008). However, the p-value for this effect, while already corrected, is only just verging on significant. It is possible that this is because of a lack of power due to a small number of participants (n=14) and small trial counts in the exclusive conditions (n=21). Interpretations of this effect are to be considered cautiously.

Five-month-old infants show a main effect of emotion on the amplitude of the N290. Consistent with predictions, Happy images elicited greater negativity at this perceptual component than did Sad images. Scott, Shannon and Nelson (2006) found that for human faces, the N290 amplitude is enhanced for familiar compared to unfamiliar trials. Thus, there is greater amplitude in response to Happy as compared to Sad faces at the perceptual components. It is also possible that this familiarity effect is due to priming effects resulting from the VPC portion of the study. Each infant completed the VPC task first, and the faces used in the VPC task were happy. It is possible that these are in fact priming effects created by the order of the tasks.

Latency analyses revealed delays in processing in the left as compared to the right hemisphere for 9-month-olds. While not all previous studies have reported latency differences with respect to hemisphere, those that do (e.g., Itier & Taylor, 2002) are consistent with the current study in favoring shorter latencies in the right hemisphere.

This is further evidence of the lateralization of face processing abilities and appears to be the strongest effect in the current study.

Attentional Component: Nc

Analyses of the Nc component suggest that 5-month-olds are not processing congruency in the current task. The current study was based on the paradigm used in Grossman and colleagues (2006), but the paradigm used here was fundamentally different from that of the current study. First, the youngest infants involved in the former study were 7-months old. Since the 9-month-olds are showing congruency-dependent effects, it is possible that 5-month-old infants are not capable of cross-modally integrating emotional information. The 5-month age group was chosen for this study, because previous research on perceptual narrowing has tested infants between 5- and 6-months-of-age to study this phenomenon (e.g., de Haan & Nelson, 1999; Pascalis et al., 2005; Kelly et al., 2007; Scott & Monesson, 2009). Additionally, because this was a study of the development of face perception, we time-locked ERP events to the presentation of the face; Grossman and colleagues (2006) time-locked to the presentation of the sound. Related, is the difference in stimulus presentation; the face, which was presented first, remained on the screen while the sound was played (Grossman et al., 2006). The separation of the two events in the current task may have created a situation in which 5-month-old infants were unable to link the two events as related.

Inconsistent with our hypotheses is the finding that Black Congruent trials elicited greater negativity than did Black Incongruent trials in the 9-month age group, while there was no significant difference between White Congruent and White Incongruent trials. It was hypothesized that the deficit in visual processing resulting from perceptual

narrowing (ORE) would interfere with the processing of congruency. Grossman and colleagues (2006) found that there was an increase in negativity in response to incongruent as compared to congruent trials. We hypothesized that this difference would be found for White faces, but not for Black faces, because the development of the ORE would interfere with processing the congruency of the information. Quite contradictory to this hypothesis, we found a congruency effect for Black faces but no significant congruency effects for White faces.

Black Congruent face/sound pairs elicit a twofold increase for the amplitude of the P400 component relative to all other conditions. Post-hoc analyses in a Race X Emotion X Congruency X Region MANOVA show that specifically, Black Happy Congruent trials elicit the greatest negativity for the Nc. Moreover, Nc amplitudes in response to Black Sad Congruent trials are about the same as those in response to White Sad Incongruent trials. Perhaps, then, what we are seeing is an accumulation of negativity in response to the unfamiliar status of Black faces. Infants hear a laughing sound and expect to see a happy face – but one with which they are familiar. It has been posited that the greater negativity seen at the Nc in response to negative as compared to positive emotion faces is because of infants' familiarity with a particular affect (e.g., de Haan et al., 2004; Grossman et al., 2006). The presentation of a familiar sound followed by a very unfamiliar face could lead to the anomalous negativity that is being elicited by Black Congruent face/voice pairs. This familiarity effect also provides a possible explanation for why the other-race dependent interaction of race and congruency is only seen in the frontal Nc region and not in the central; more attentional resources are being recruited in an attempt to make sense of this extremely unfamiliar stimulus.

While we did not get the expected interaction between cross-modal processing of congruency and the development of the ORE by 9-months-of-age, there does seem to be a disruption in the processing of emotion when viewing other-race faces at 9-months. While perceptual components revealed emotion-dependent effects in 5-month-olds, there was no evidence of 9-month-olds differentiating emotions. It was hypothesized that, due to possible interference caused by the other-race effect (O'Toole et al., 1996), the presentation of an other-race face would disrupt the processing of congruency. While this effect was not found, P400 amplitude responses to Black faces were diminished (M=10.27, SD=2.77; M=13.70, SD=2.35, respectively) compared to White faces (M=17.25, SD=2.42; M=18.25, SD=2.40, respectively) (See Figure 20). The support this gives for the hypothesis that the other-race effect would interfere with emotion processing is questionable. First, one would expect that if this were the case, we would also see a difference between Black Happy and White Happy trials; there is no such difference. Second, the analyses on congruency-dependent effects could not include emotion as a level, because participants did not complete enough trials to analyze the data in this way. Additionally, the component for which congruency effects are found (Nc) is not the same as the component for which race seems to be interacting with emotion (P400). Nonetheless, while congruency was not affected in the expected way, it seems feasible to suggest that emotion processing was disrupted by the presentation of an other-race face. Testing more subjects in order to reanalyze the data may reveal these effects to be significant.

Summary and Limitations

The current study has only partly replicated previous findings indicating the development of a visual perceptual bias, the other-race effect, from 6- to 9-months-of-age (Kelly et al., 2007). While novelty preferences were as expected, pair-wise comparisons suggested that 9-month-olds were not treating same- and other-race faces differently enough to be detected by statistical tests. It is possible that this is due to the presence of a patterned background that causes distractions, or to the use of a VPC paradigm instead of habituation. However, ERP and VPC results provide converging evidence supporting the theory of perceptual narrowing. Five-month-old infants exhibit no race-dependent effects on either behavioral (VPC) or electrophysiological (ERP) measures of visual discrimination, but 9-month-olds do.

The current study also attempted to determine whether or not previously established (Grossman et al., 2006) cross-modal integration abilities are affected by the other-race effect, and how this may be reflected in brain development as examined via ERPs. While the expected result was not found, it is interesting that 5-month-old infants show emotion-dependent effects and 9-month-olds do not. It has already been established that infants are able to distinguish among emotions by this age (Leppanen et al., 2007). As previously suggested, perhaps the ORE interferes with the processing of emotional faces. However, this interpretation must be considered carefully, as the lack of effects does not prove a lack of ability or processing. Examination of effect size power in these analyses suggests that more participants and/or more trials per condition would be needed in order to draw firm conclusions.

To this effect, a study further examining the interaction of emotion and race would be beneficial. The conclusions that can be drawn concerning how the ORE interferes with

emotion processing are somewhat ambiguous, due to the complexity of the current task, which was not designed for this purpose. A study that presents Happy and Fearful or Sad faces of different races to infants, without the additional congruency task, is needed. An adult study would also help to elucidate the role of race-based visual biases in the processing of such perceptual characteristics as emotion.

Unfortunately, the population of participants used in this study was too homogenous to test whether the same effects would be found for African American infants in response to Caucasian faces. In the future, a study should be conducted to replicate this finding with other racial groups. Additionally, it would be beneficial to recruit a population of infants who have a more diverse racial experience, so that one can correlate the development of perceptual abilities with different levels of experience. A follow-up study with adults that documented their experience with own- and other-race faces would help to determine the possible experience-based factors contributing to the development of the ORE. Future research should be directed at further elucidating the role of experience in the development of the other-race effect, as well as how this low-level perceptual bias may influence other areas of cognition, including not just face and emotion processing, but how these changes may be manifest in aspects of social cognition.

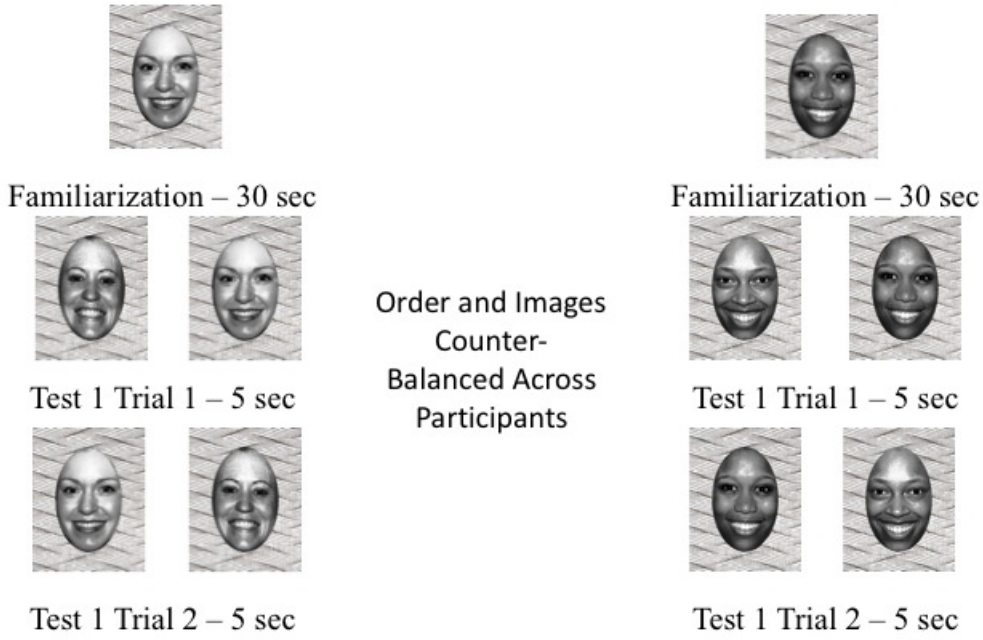

Figure 1*:* VPC Task. The above figure shows how the VPC is run. Test 1/Test 2 trials were counterbalanced across participants so that half of the babies saw the Caucasian faces first, and half saw the African American Faces first. There were also two separate sets of face stimuli, the order of which was also counterbalanced across participants.

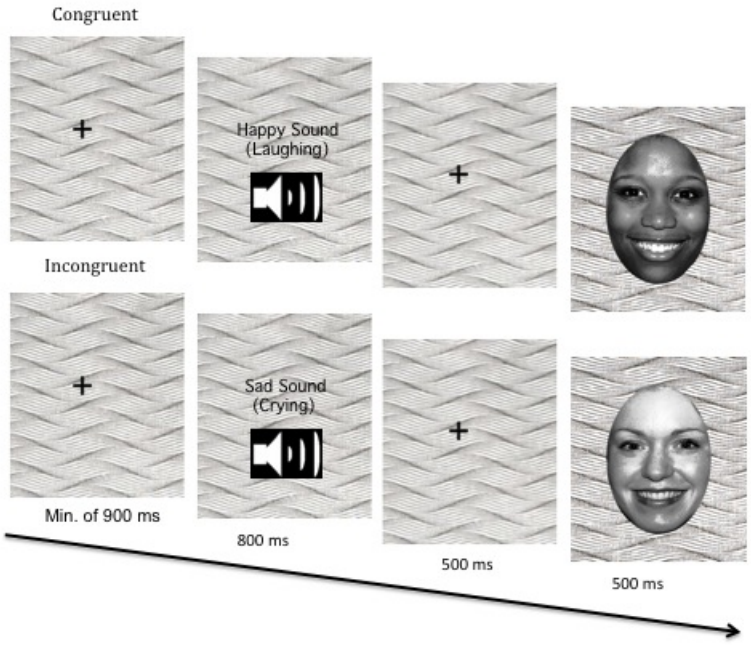

Figure 2: ERP Task. The ERP task will be presented as indicated above. Each trial presents the participant with a black fixation cross presented on the grey and white pattered background seen behind the face. An 800ms clip of a female voice either laughing or crying is then played, followed by another black fixation cross on the background for 500ms. Finally, either a smiling or frowning female face (only smiling faces for infant paradigm) is presented for 500ms. Adults are asked to indicate via button press whether the match is congruent or incongruent.

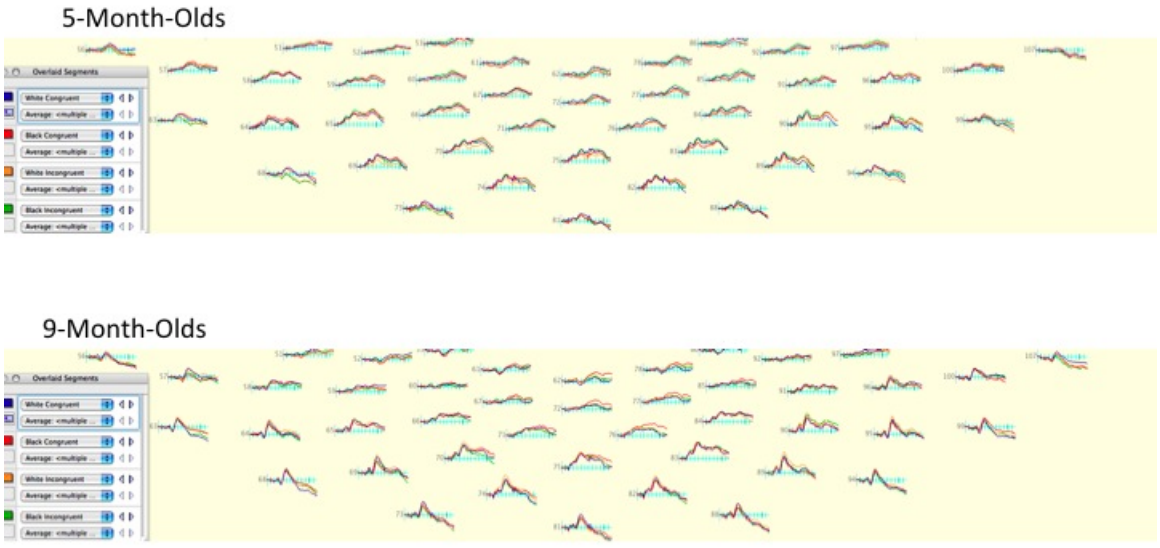

Figure 3*:* P400 Topo Plots. Topo plot showing P400 distribution in 5- and 9-month-olds.

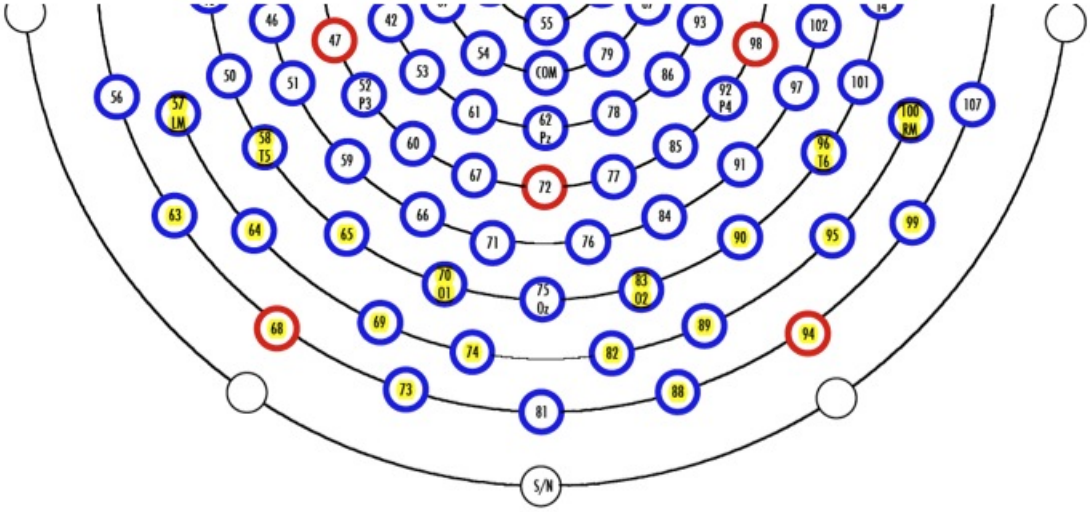

Figure 4: Electrode groupings for N290 and P400 analyses. Layout of electrode groupings for N290 and P400 components.

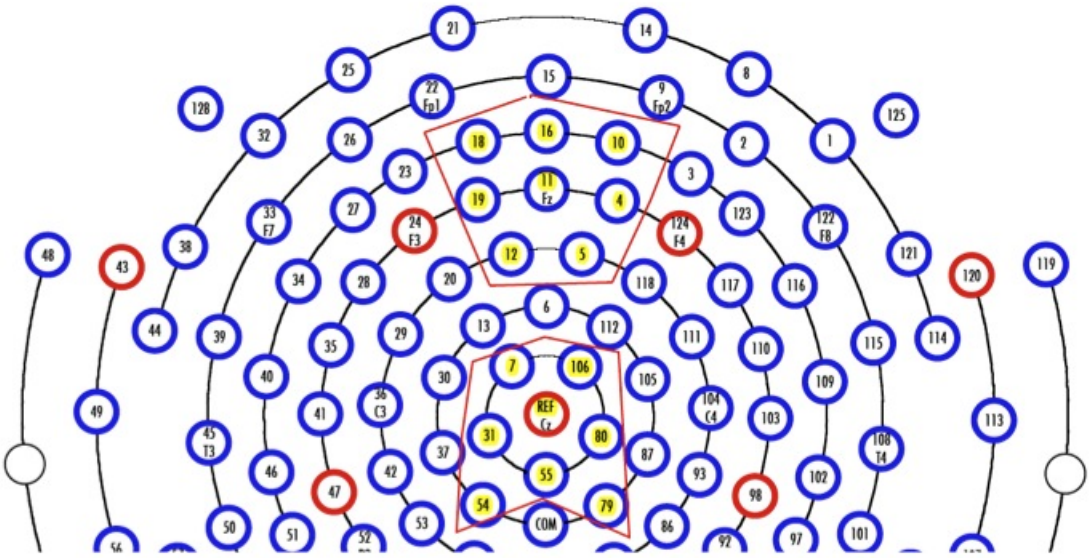

Figure 5: Electrode groupings for Nc analyses. Layout of electrode groupings for Nc component.

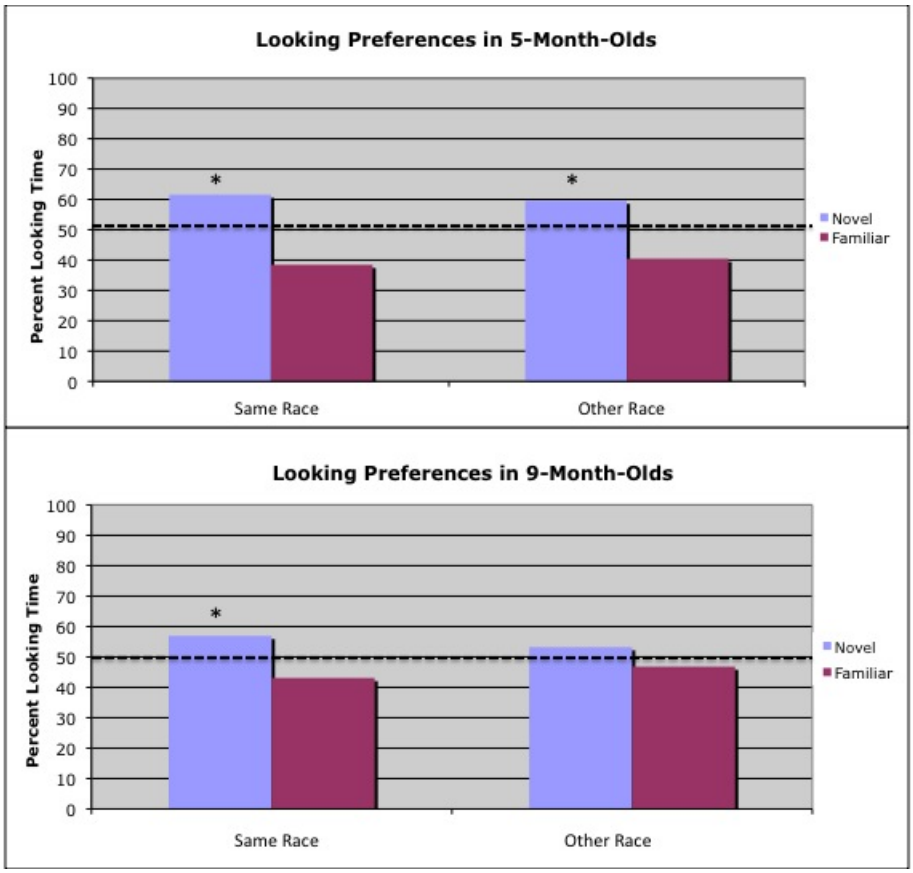

Figure 6*:* Results of behavioral data indicate that 5-month-olds are showing novelty preferences for both same- and other-race faces, but the 9-month-olds are only showing novelty preferences for same-race faces. This is an indication of the other-race effect.

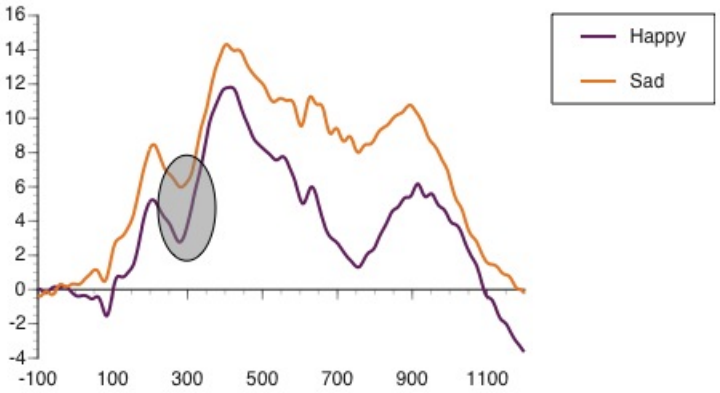

Figure 7: N290 Main Effect of Emotion for 5-Month-Olds. There was a main effect of emotion for 5-month-olds for the N290 component. More negative amplitudes were elicited by Happy compared to Sad faces.

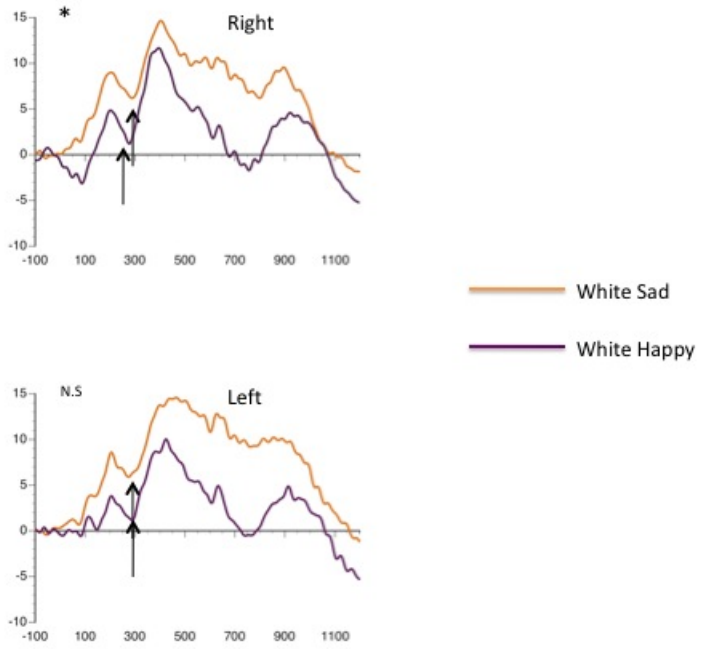

Figure 8: N290 Race X Emotion Interaction for 5-Month-Olds. Race X Emotion X Hemisphere interaction for the N290 at 5-months indicates faster processing of White Happy faces in the Right hemisphere only.

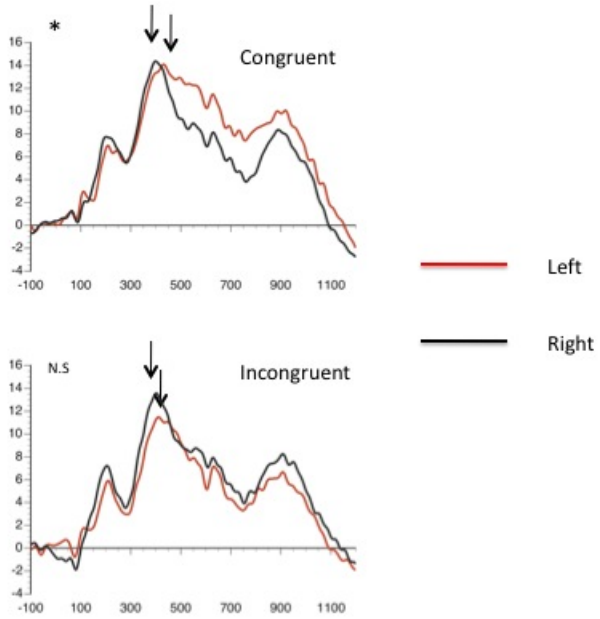

Figure 9: P400 Congruency X Hemisphere Interaction Effect for 5-Month-Olds. A significant Congruency X Hemisphere interaction effect for the P400 component at 5-months indicates faster processing of Congruent trials only in the Right as compared to the Left hemisphere.

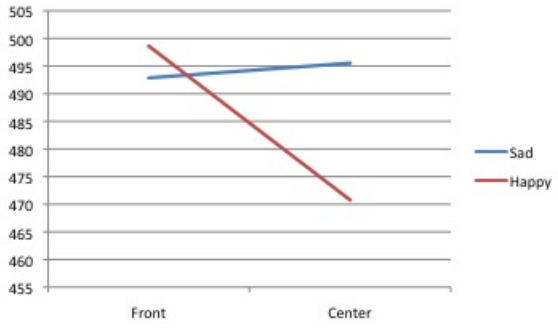

Figure 10*:* Nc Emotion X Region Interaction Effect for 5-Month-Olds. A significant 2-way interaction (Emotion X Region) at the Nc for 5-month-olds revealed that this effect was being driven by shorter latencies to Happy trials at the central location compared to the frontal location and compared to Sad trials at the central location. However, neither of these comparisons was significant.

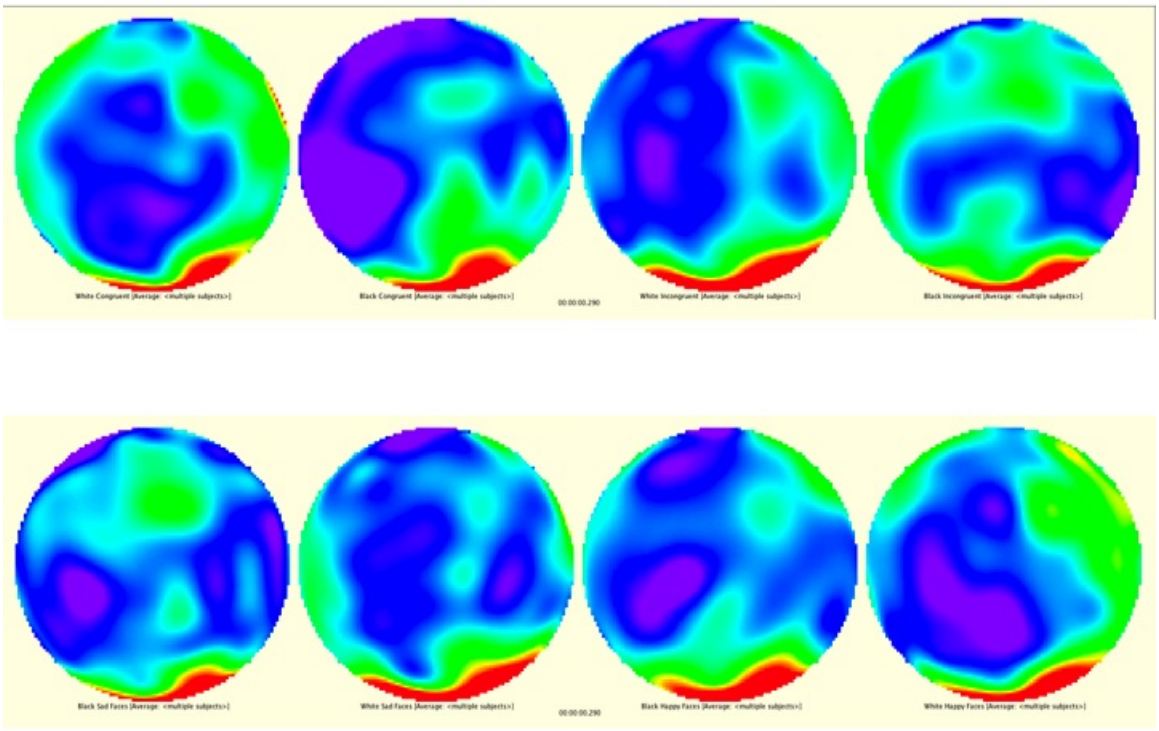

Figure 11*:* N290 Main Effect of Hemisphere for 9-Month-Olds, R X C X H.

Figure 12: N290 Main Effect of Hemisphere for 9-Month-Olds, R X E X H.

In a Race X Congruency X Hemisphere and a Race X Emotion X Hemisphere comparison, respectively, main effects of hemisphere revealed more negative amplitudes at the N290 in the Left as compared to the Right hemisphere in 9-month-olds.

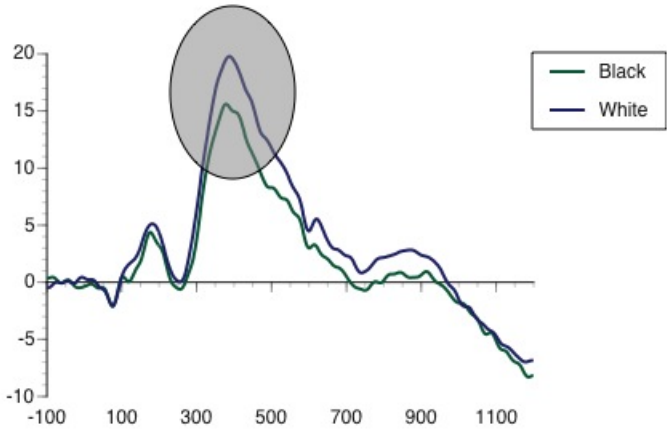

Figure 13*:* P400 Main Effect of Race for 9-Month-Olds. A main effect of race on the P400 in 9-month-olds is consistent with hypotheses regarding the development of the other-race effect.

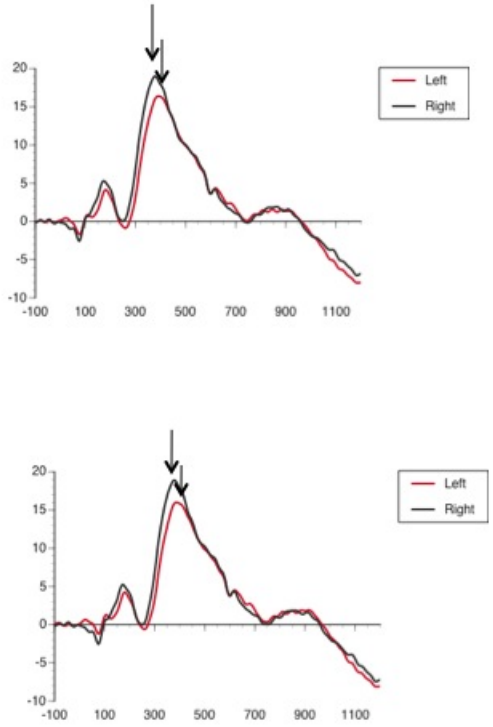

Figure 14: P400 Main Effect of Hemisphere for 9-Month-Olds, R X C X H.

Figure 15: P400 Main Effect of Hemisphere for 9-Month-Olds, R X E X H.

In 9-month-olds, a Race X Congruency X Hemisphere and a Race X Emotion X Hemisphere comparison, respectively, shorter latencies at the P400 in the Right as compared to the Left hemisphere are consistent with previous literature reporting right lateralization of face processing abilities.

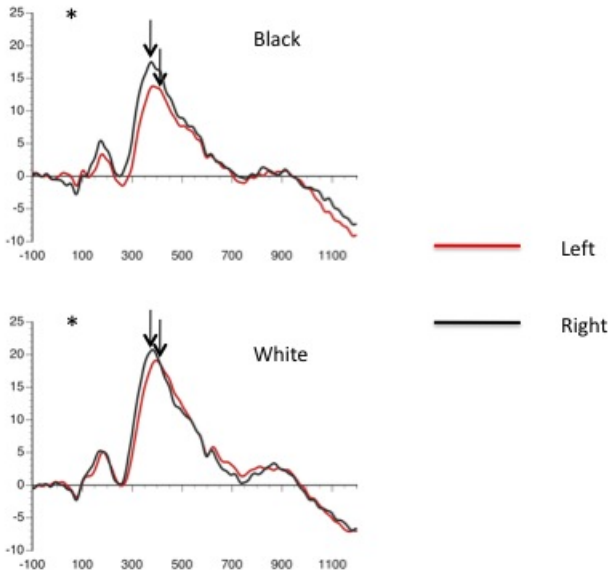

Figure 16*:* P400 Race X Hemisphere Interaction Effect for 9-Month-Olds. In 9-month-olds, a Race X Hemisphere interaction effect at the P400 component indicates faster processing in the Right as compared to the Left hemisphere for both Black and White faces.

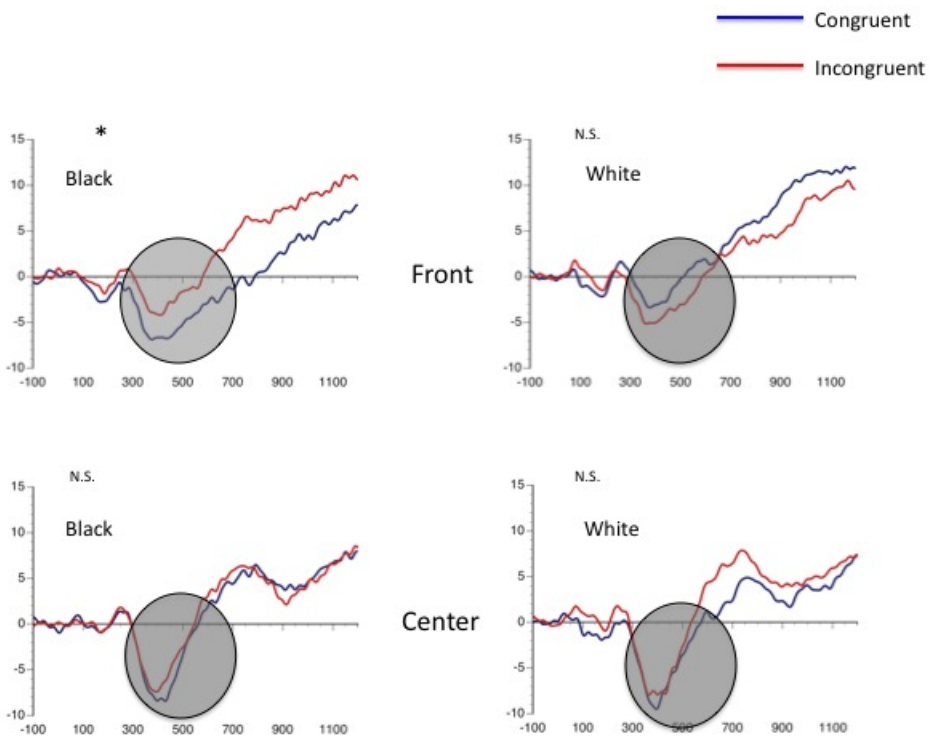

Figure 17*:* Nc Race X Congruency Interaction Effect for 9-Month-Olds. A Race X Congruency X Region analysis of the Nc component in 9-month-olds reveals an unexpected result. Larger amplitudes to Black Congruent as compared to Black Incongruent trials, with no difference between White Congruent and White Incongruent trials, points to an anomaly in the responses to Black Congruent trials.

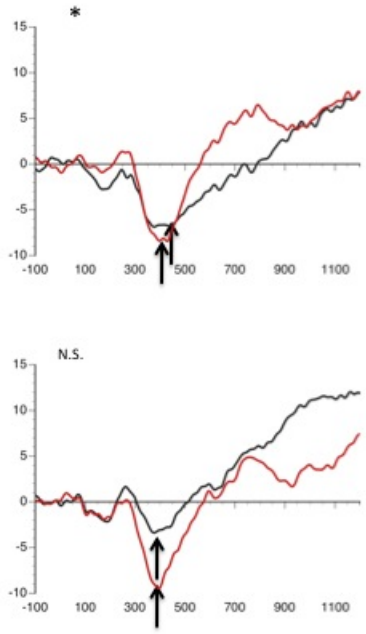

Figure 18*:* Nc Congruency X Region Interaction Effect for 9-Month-Olds. Latency differences between Front and Central Nc locations for Black Congruent trials, but not White Congruent trials, suggests a delay in the processing for other-race faces in 9-month-olds.

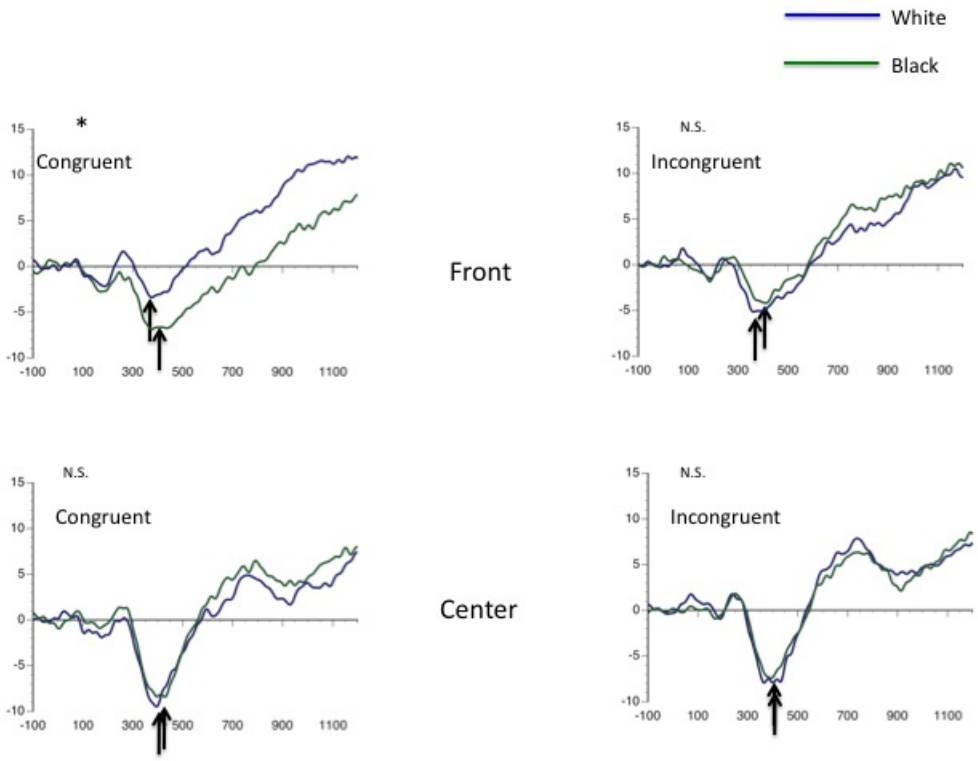

Figure 19*:* Nc Race X Congruency Interaction Effect for 9-Month-Olds. Longer latency responses at the Nc for 9-month-olds in response to Black Congruent compared to White Congruent trials indicates a lack of familiarity with Black faces.

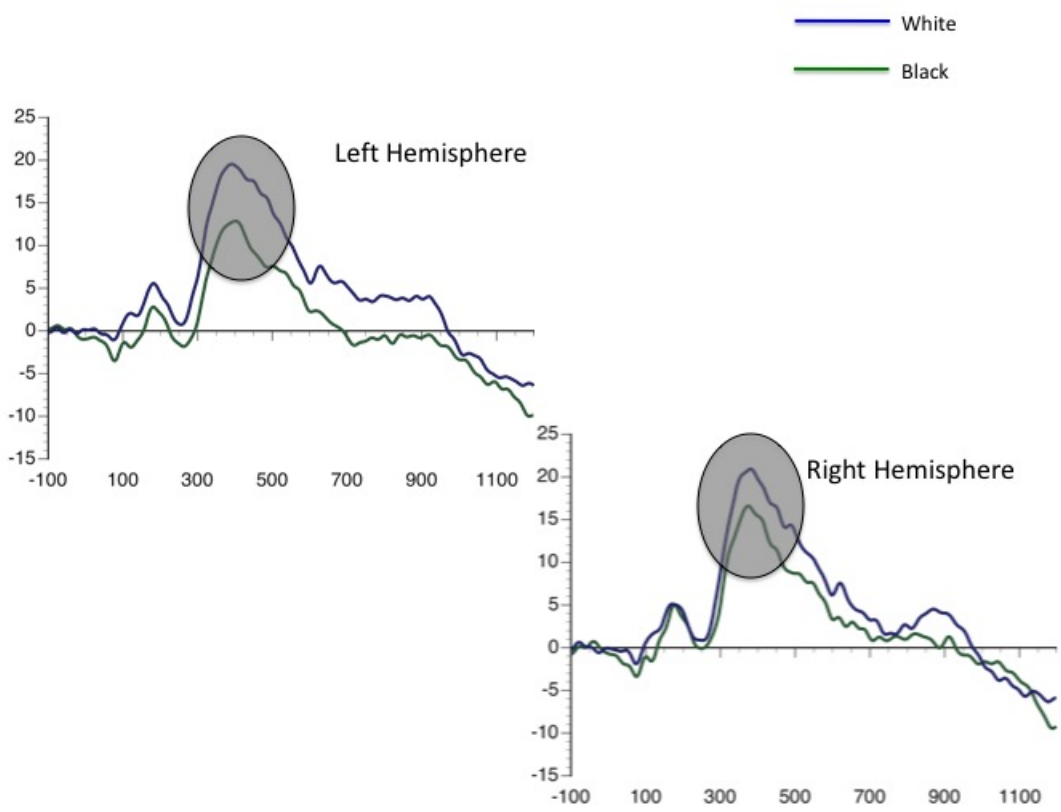

Figure 20*:* P400 Effects of Race on Emotion Processing at 9-Months. Dampening of P400 responses to Black Sad compared to White Sad faces in both the left and right hemisphere suggest an interference of race with emotion processing at 9-months-of-age.

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